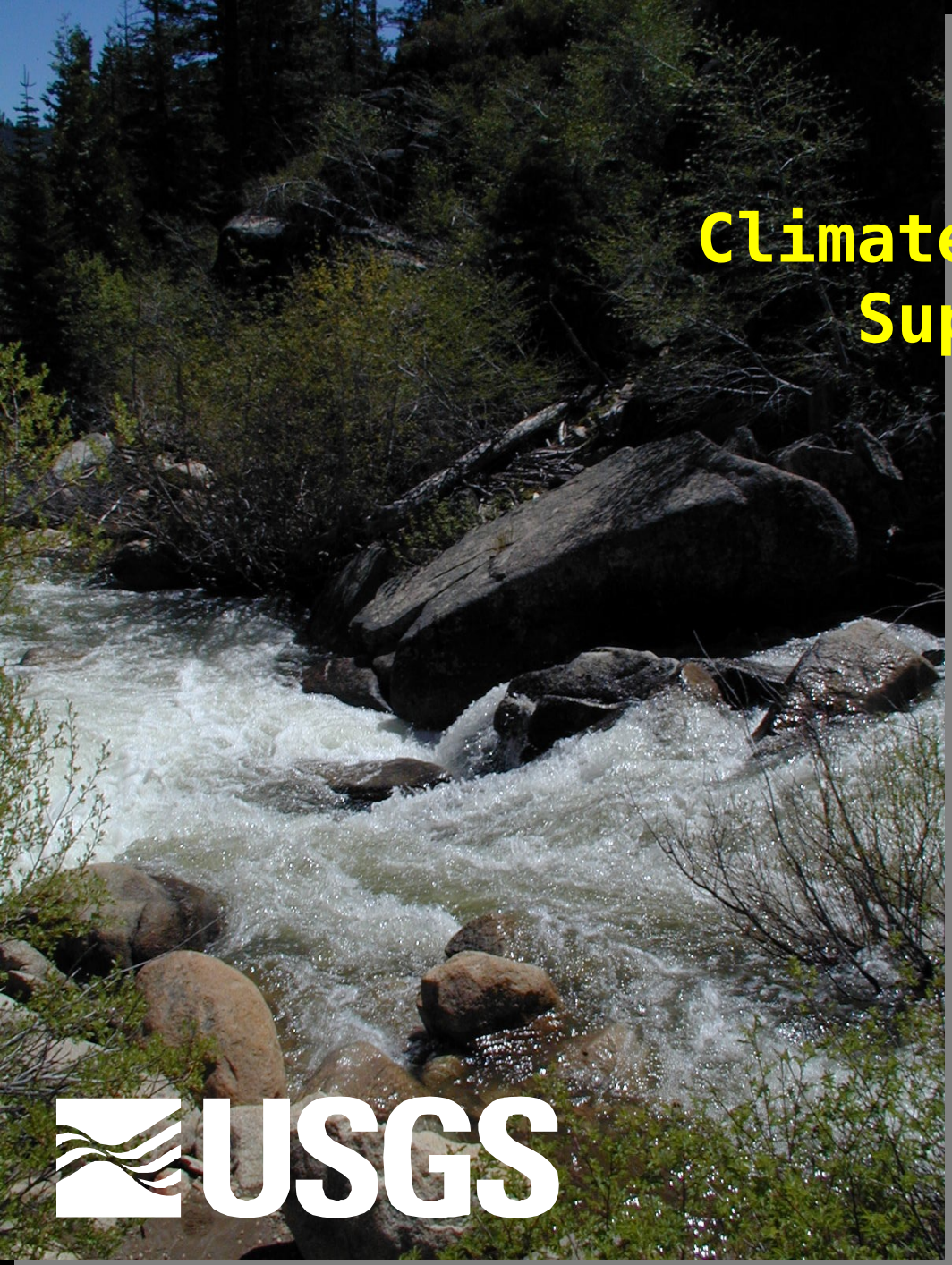
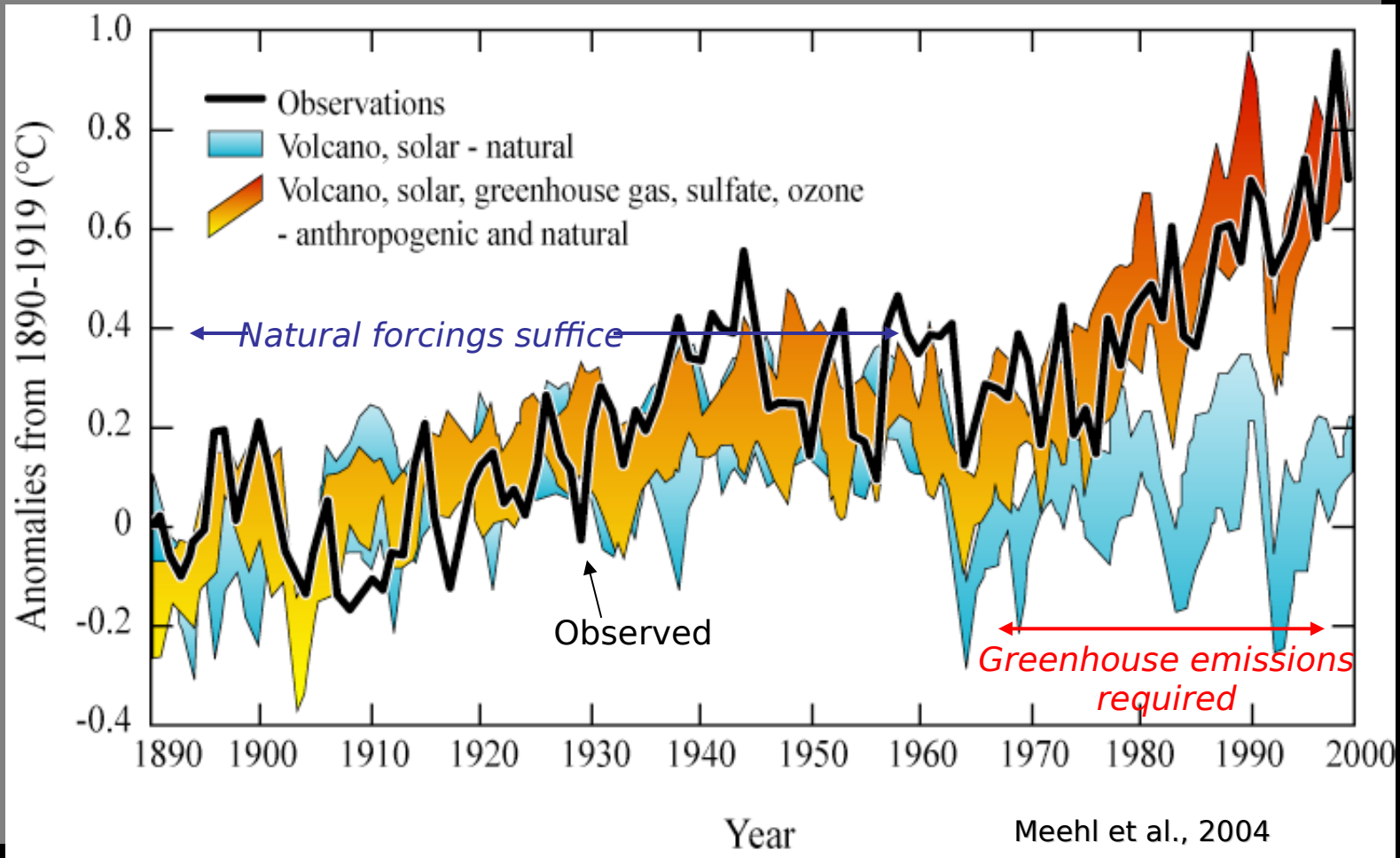


Climate Change and Water Supplies in the West

Michael Dettinger, USGS

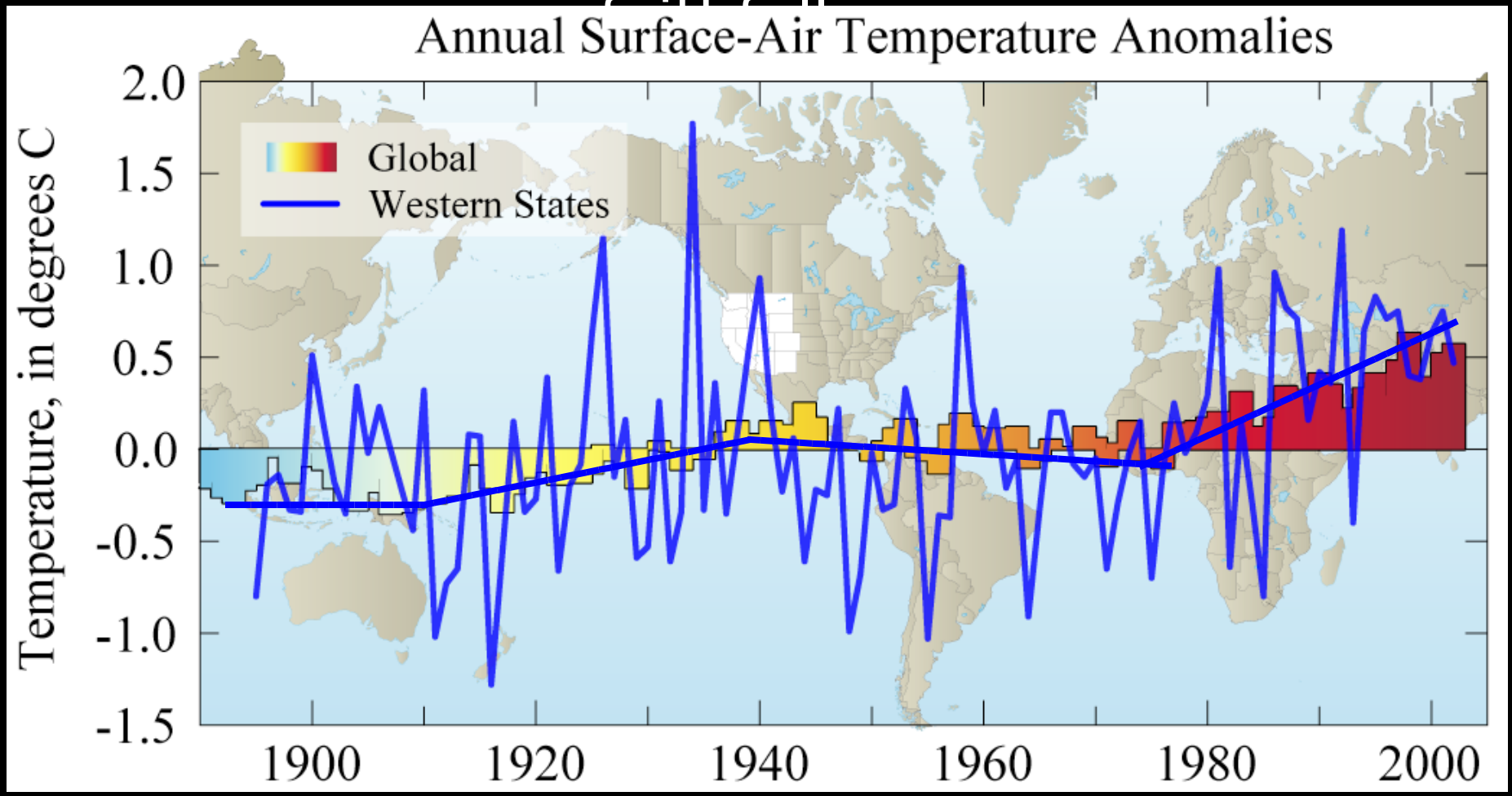
During the past 30 years--and in the near-term future--natural climate variability has been *augmented* by warming trends associated with increases in the global greenhouse effect.

Climate-model simulations of global-



Meehl et al., 2004

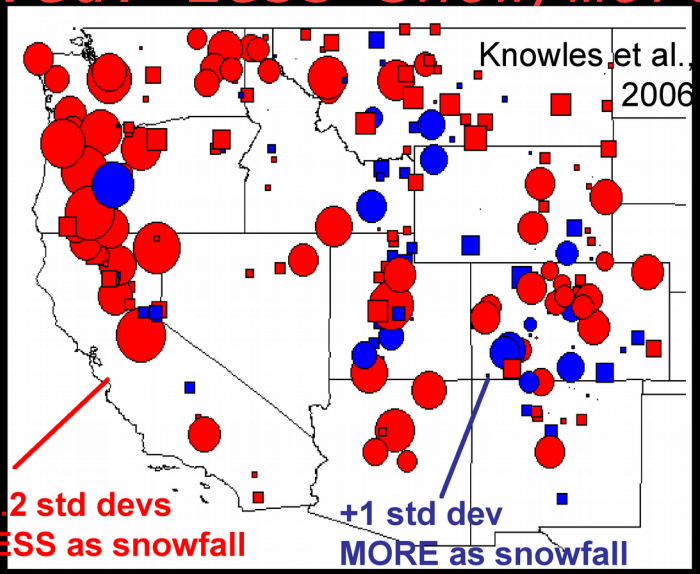
...and observed temperatures in the Western States have followed pretty



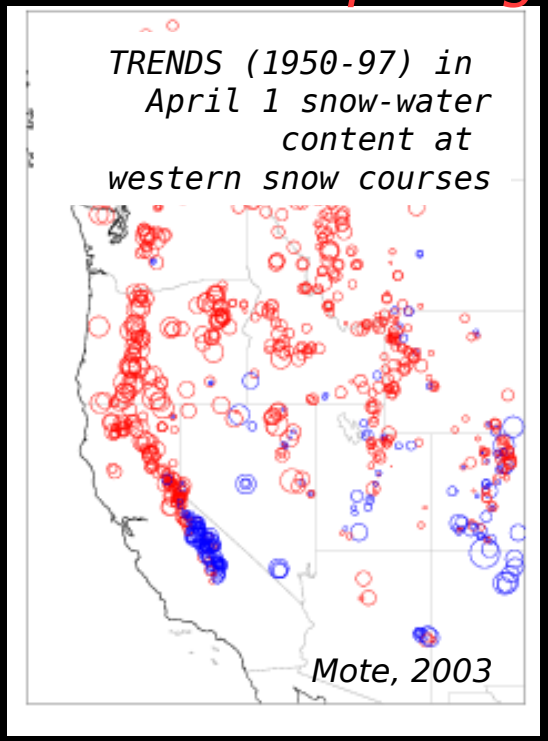
USGS

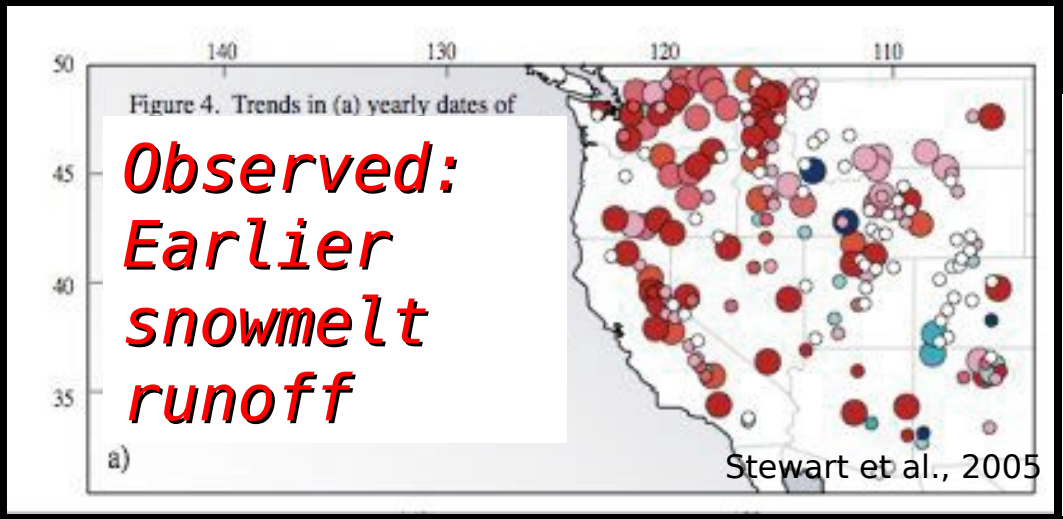
Warming already has driven observable hydroclimatic change

Observed: Less snow/more rain

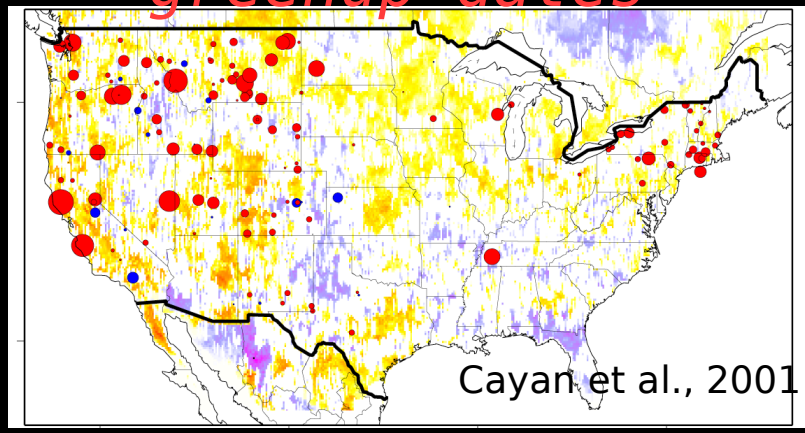


Observed: Less spring snowp

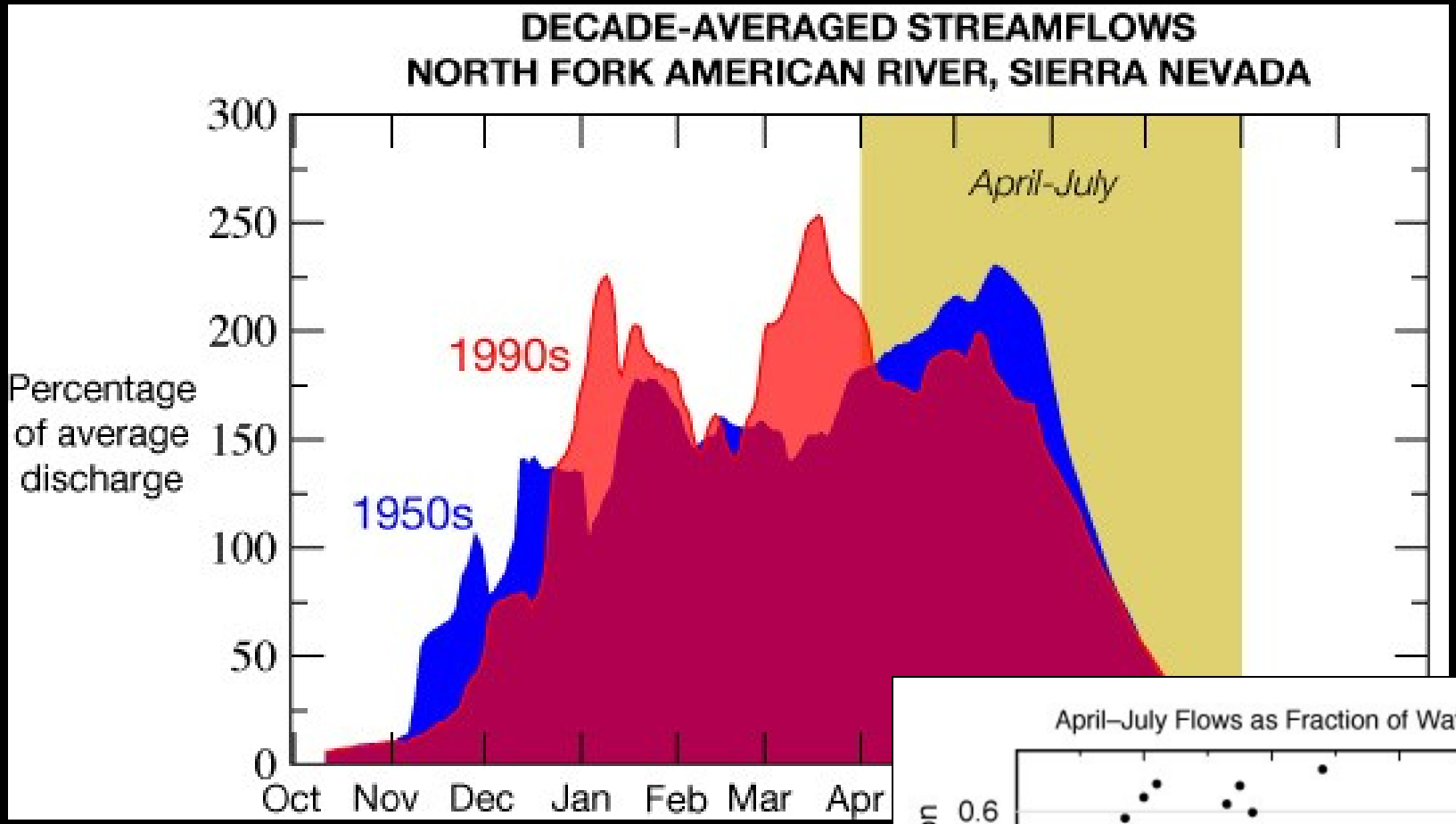


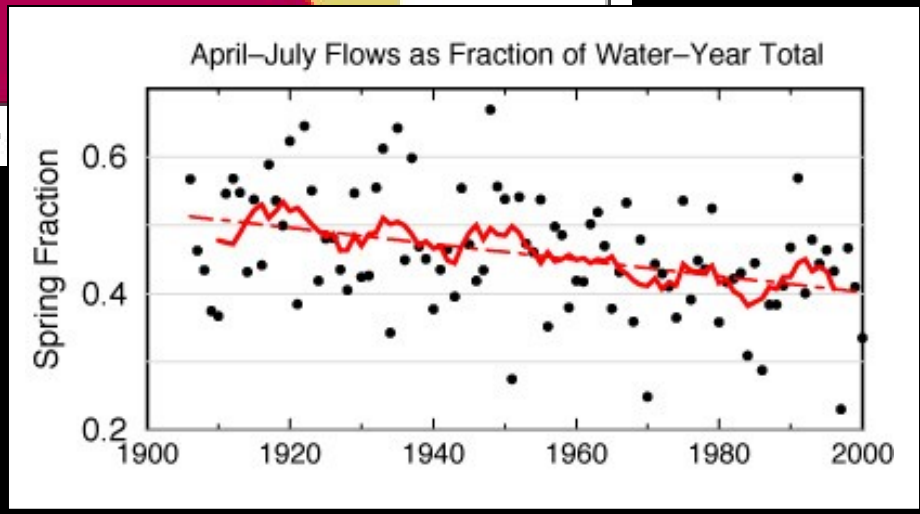


Observed: Earlier greenup dates



As a result of these trends, the warm-season fraction of annual streamflow has declined.



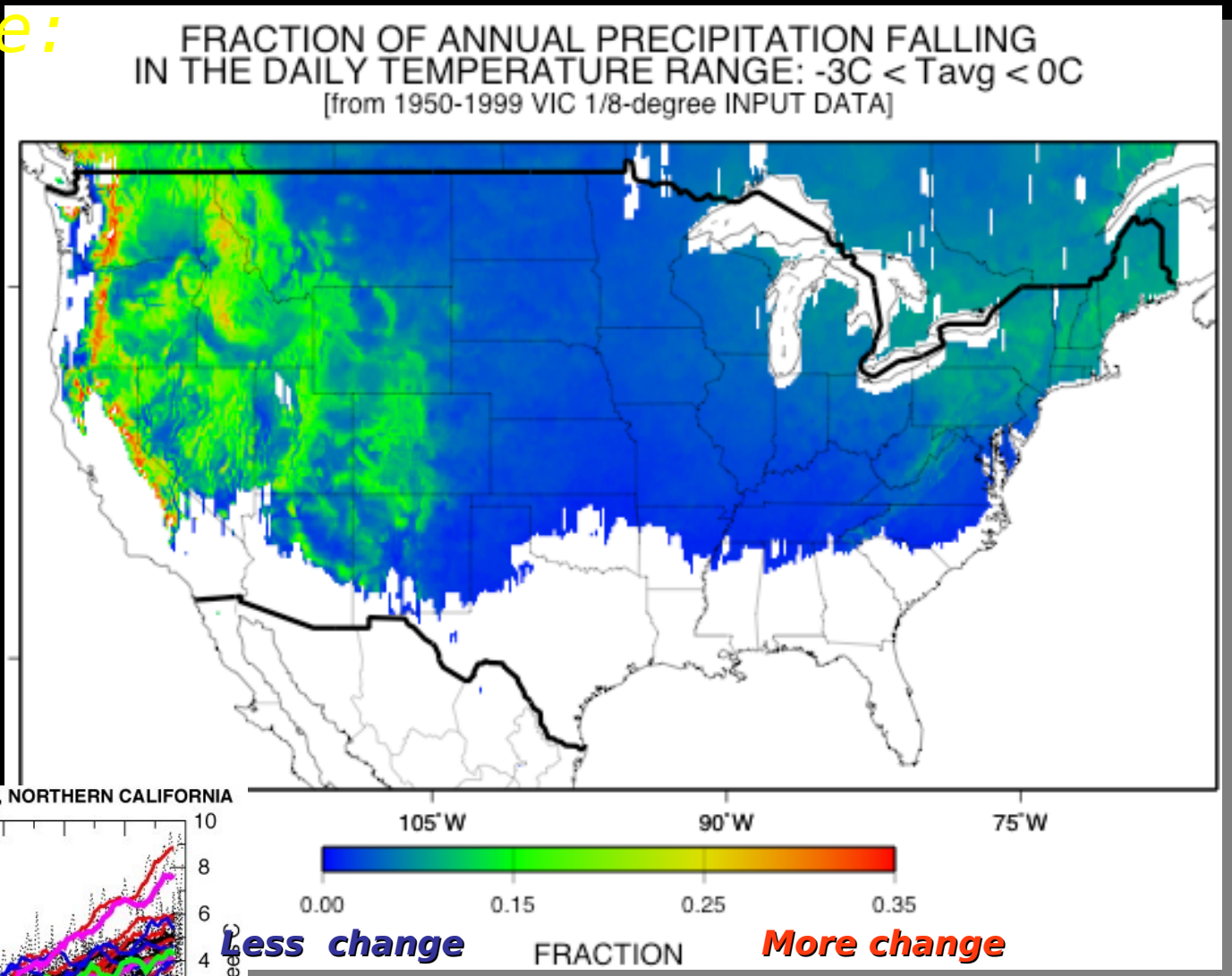


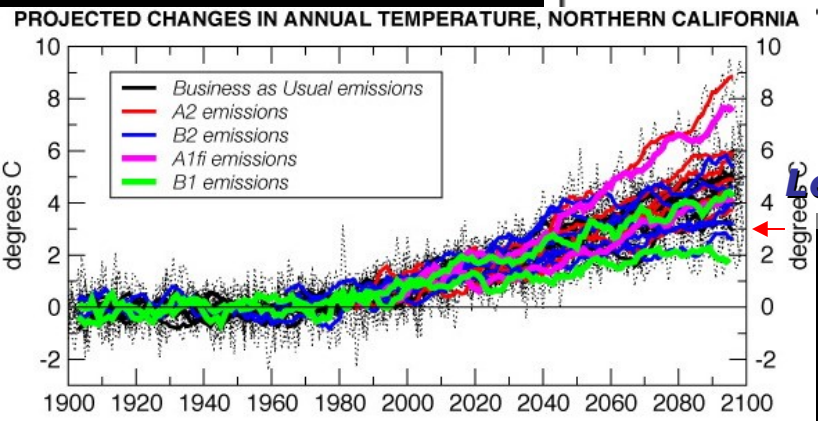
Roos, 1989, 1991; Dettinger and Cayan, 1995; Stewart et al 2005

USGS

To put these levels of of warming into perspective:

What fraction of precipitation historically fell on days with average temperatures just below freezing?



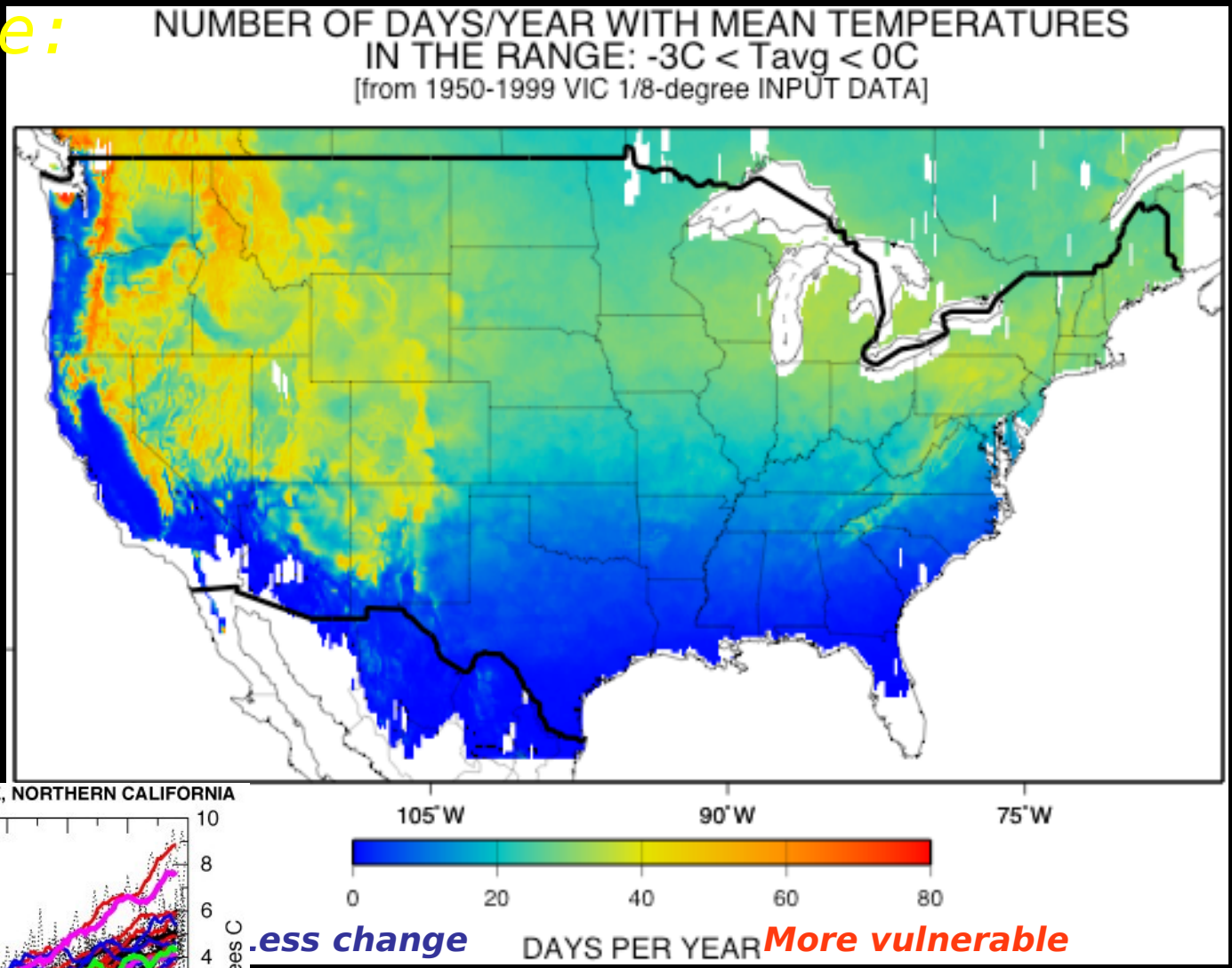


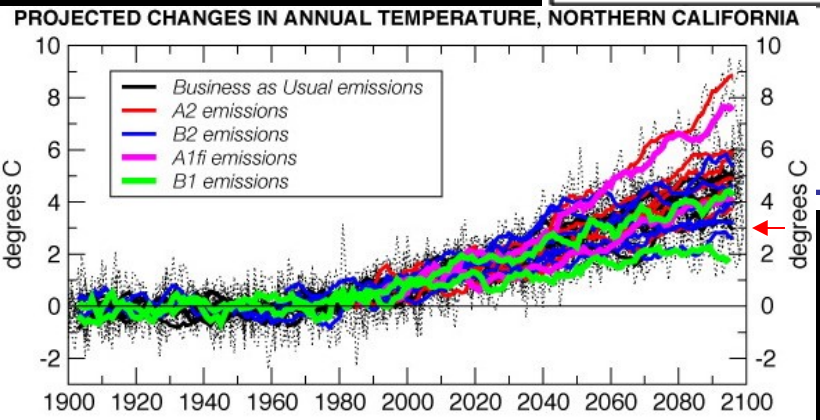
"Rain vs Snow"

Computed from UW's VIC model daily INPUTS (Bates

To put these levels of of warming into perspective:

How many days/year historically were just below freezing?



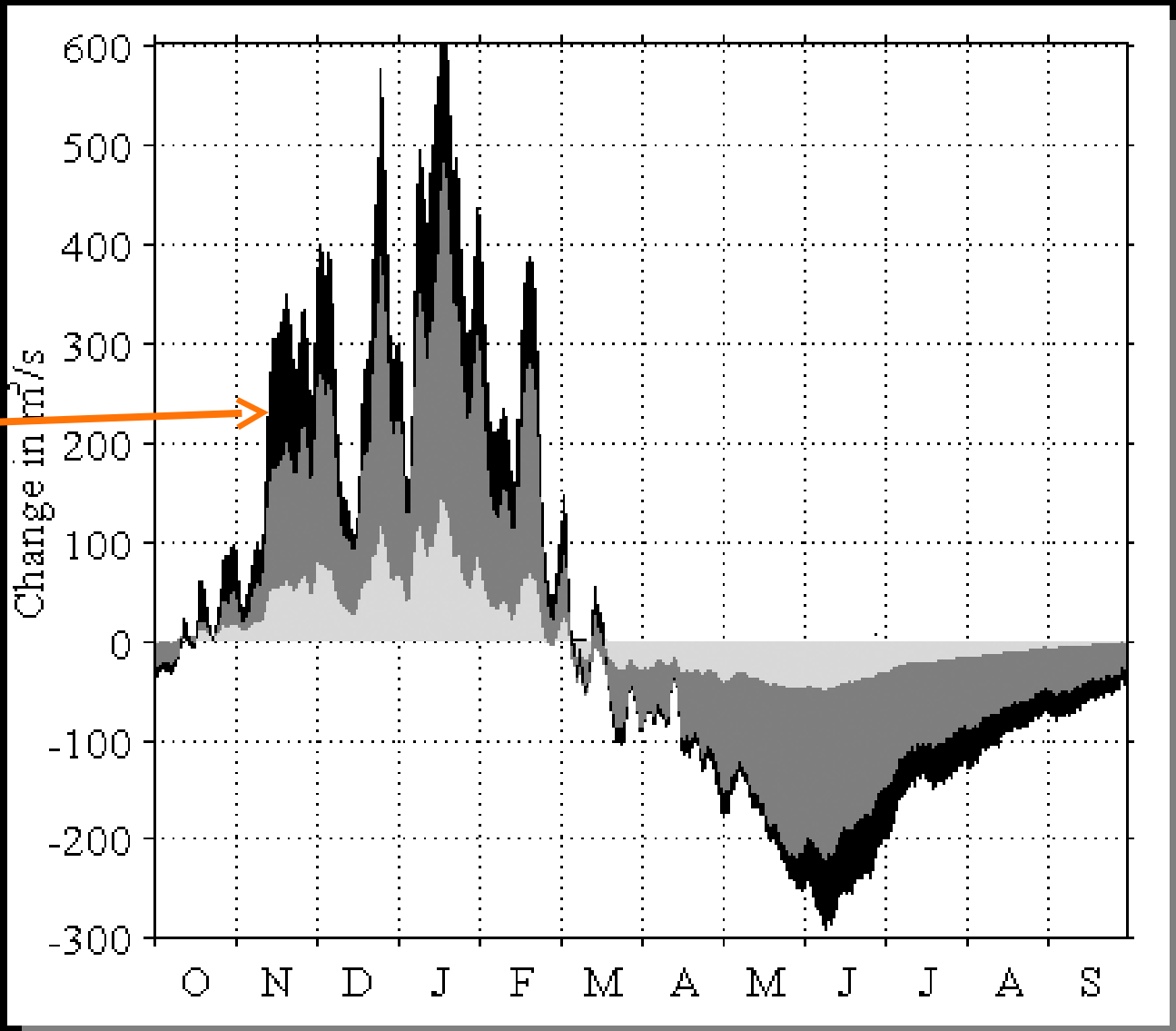


"Duration of Snowpack"

Computed from UW's VIC model daily INPUTS (Bates

Changes in Sierra Nevada Outflow, 2060 – 2

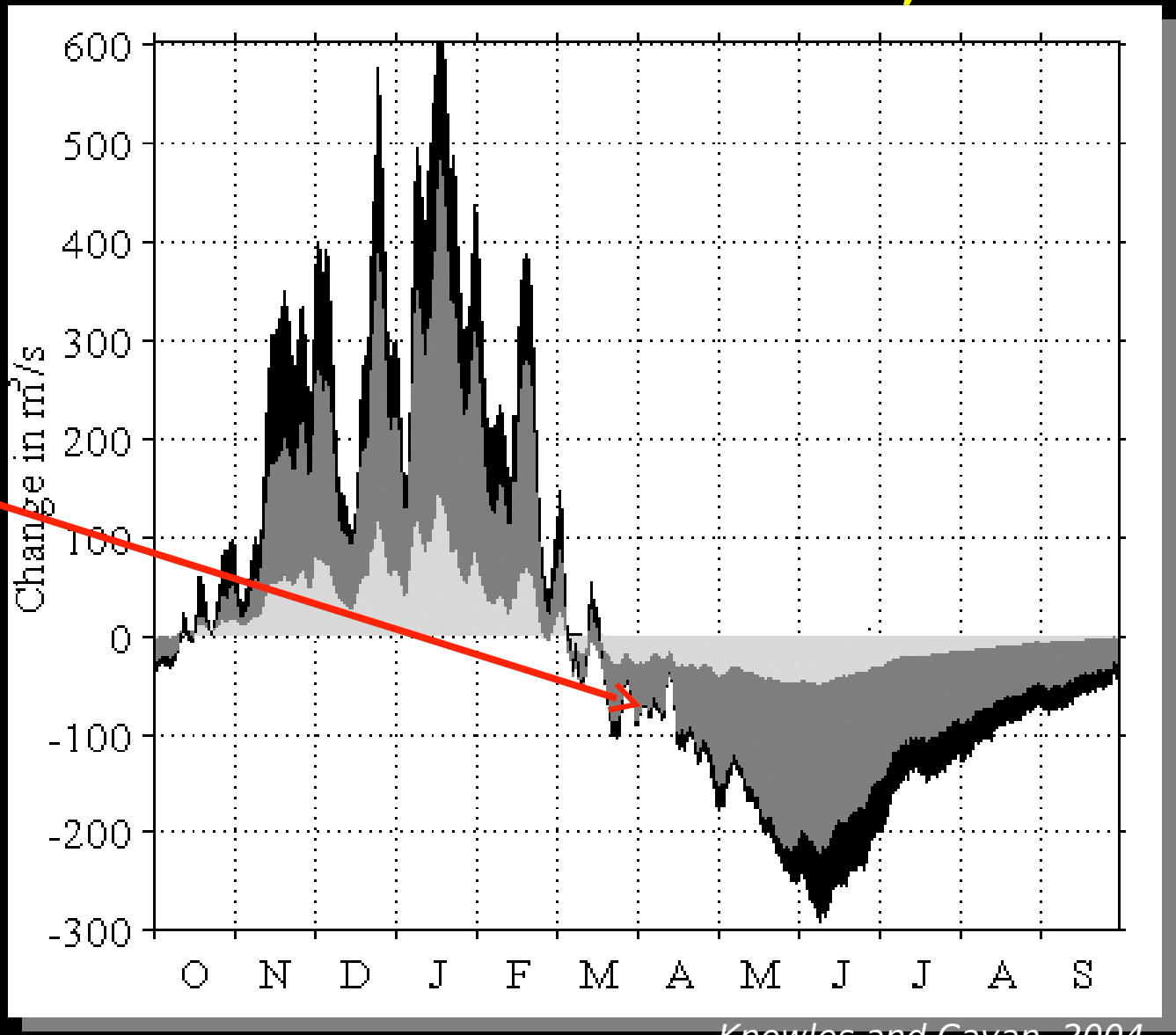
Besides changing flow seasonality, these changes may bring more severe winter floods in at least some settings...



Knowles and Cayan, 2004; http://www.fs.fed.us/psw/cirmount/ /meetings/agu/pdf2006/dettinger_etal_poster_AGU2006.pdf

Changes in Sierra Nevada Outflow, 2060 – 2

...and, with earlier runoff/ET and warmer summer temperatures, much drier springs and summers.

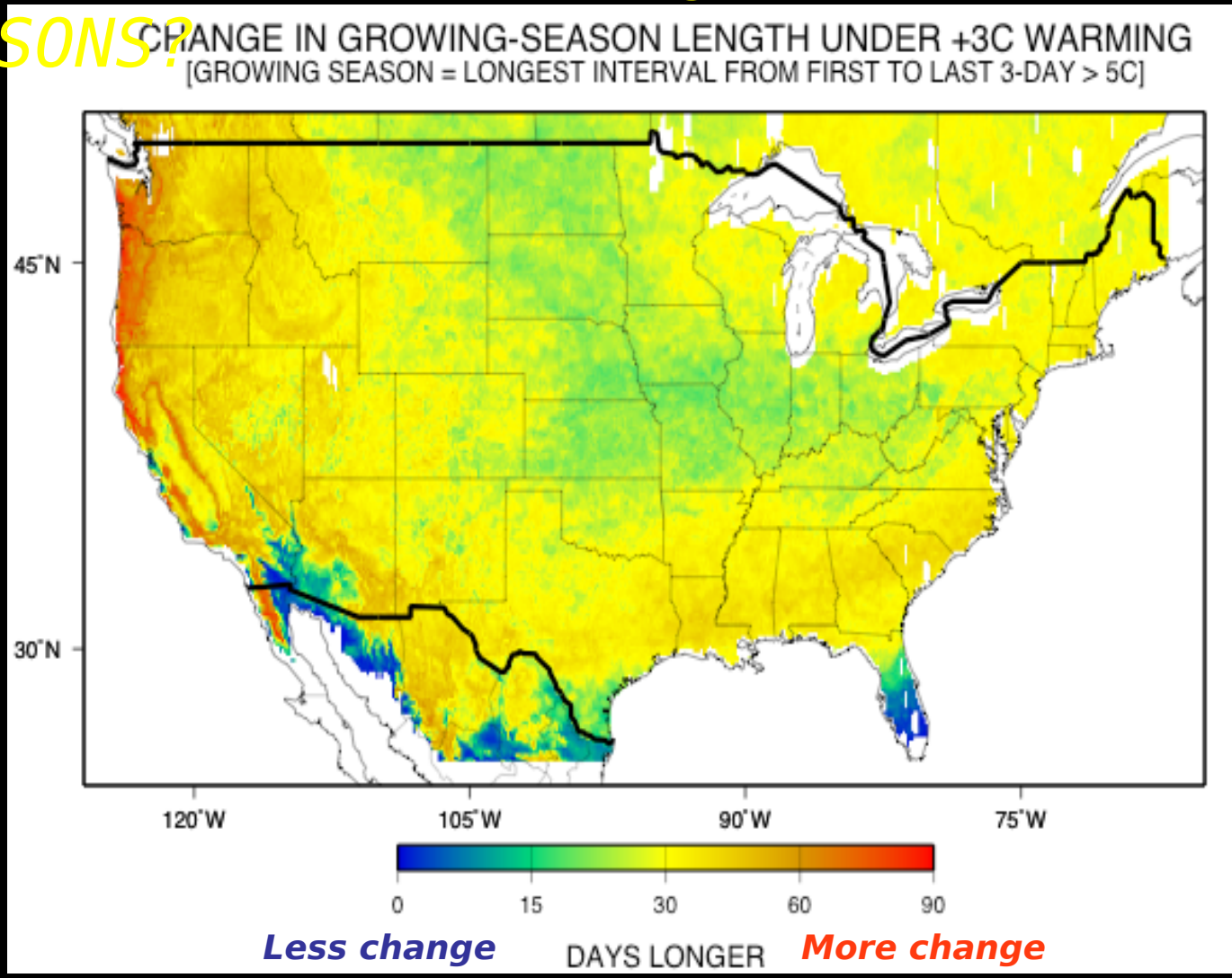


Knowles and Cayan, 2004
Dettinger et al., 2004

USGS

How much would a +3ºC warming matter to GROWING SEASONS?

How many days historically were just below the onset temperatures for growing seasons ?

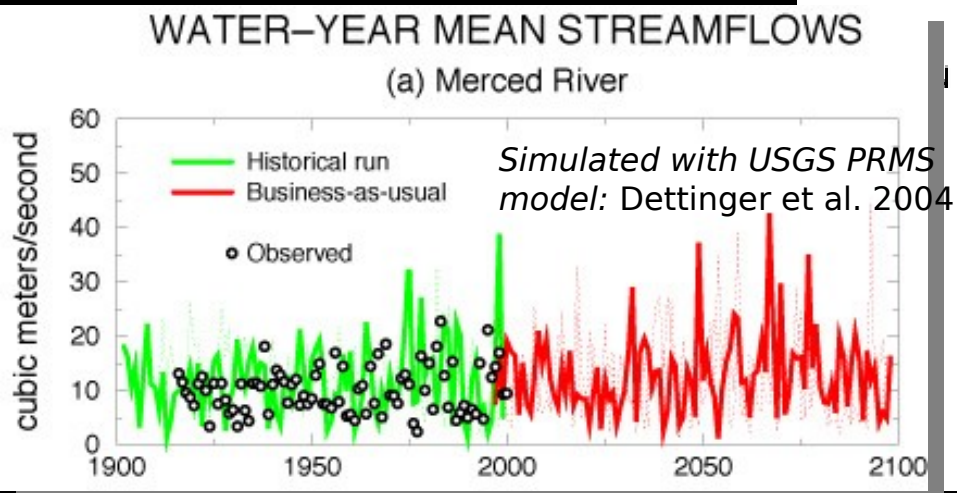


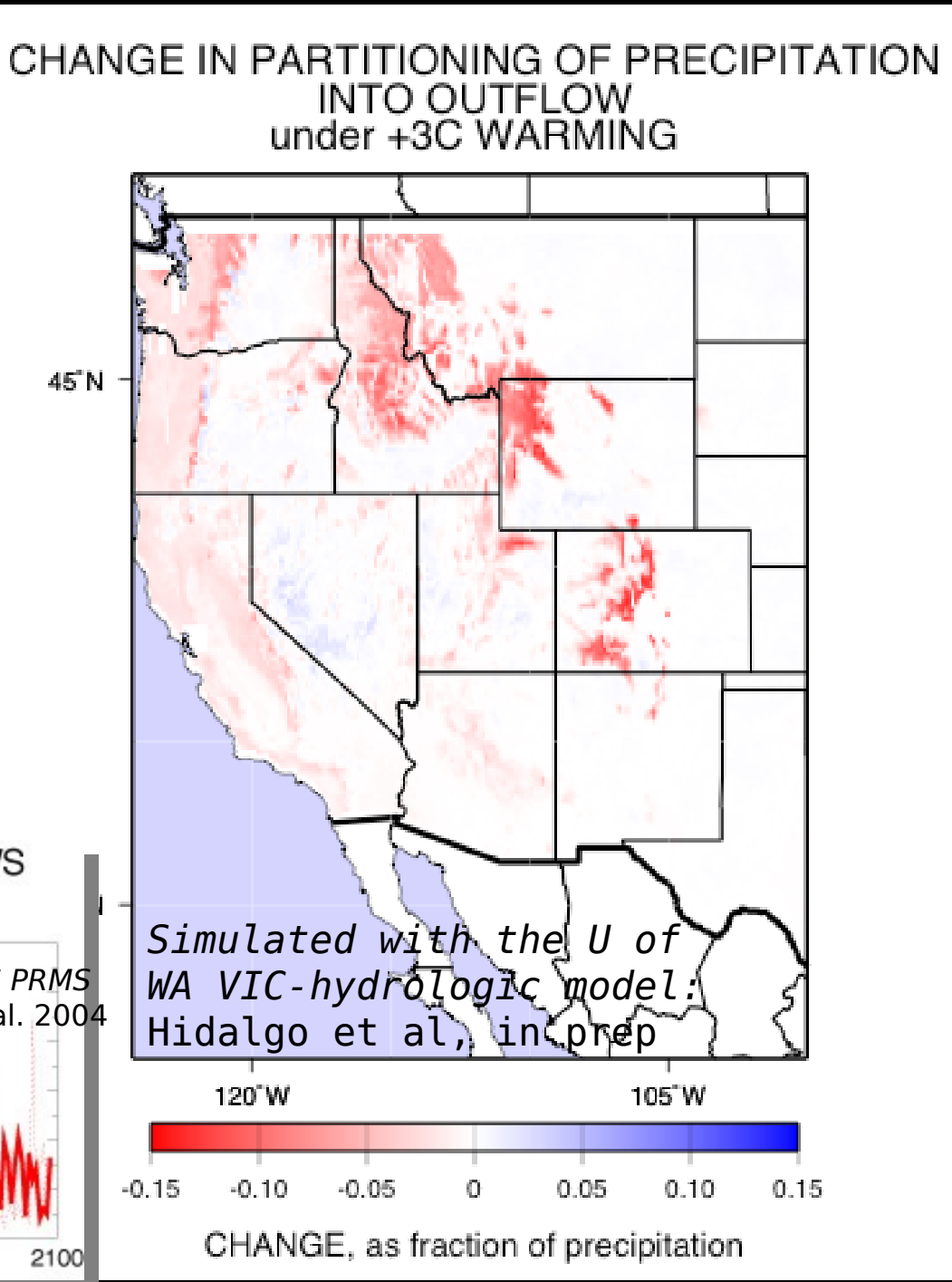
Growing Season Length

Computed from UW's VIC model daily INPUTS (ala

Overall, though, these seasonal-scale changes pretty much balance each other, so that runoff+recharge may not change much.

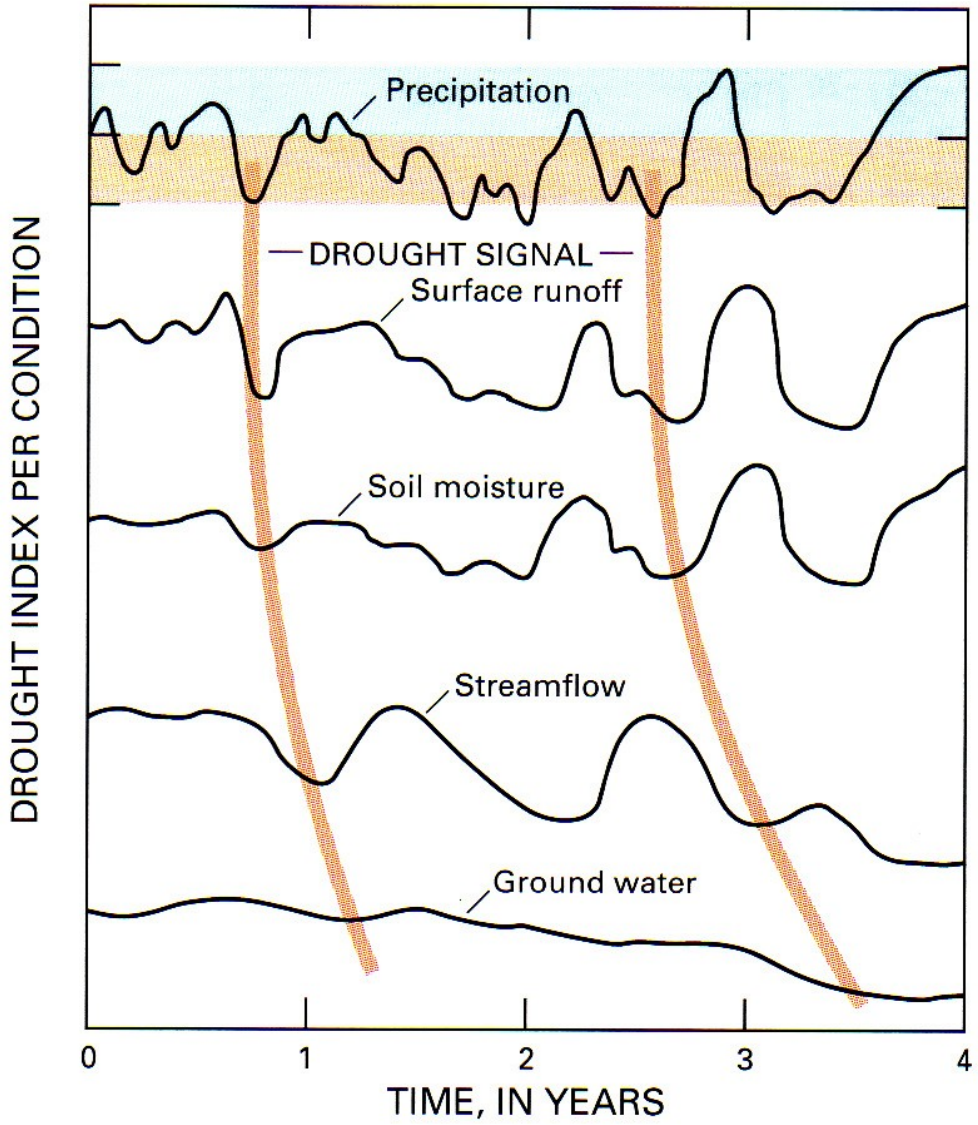
SIMULATED CHANGES IN RUNOFF+RECHARGE under a uniform +3ºC warming





Aquifers respond preferentially to lowest frequency climatic variations

This means that aquifers may express climate TRENDS disproportionately.

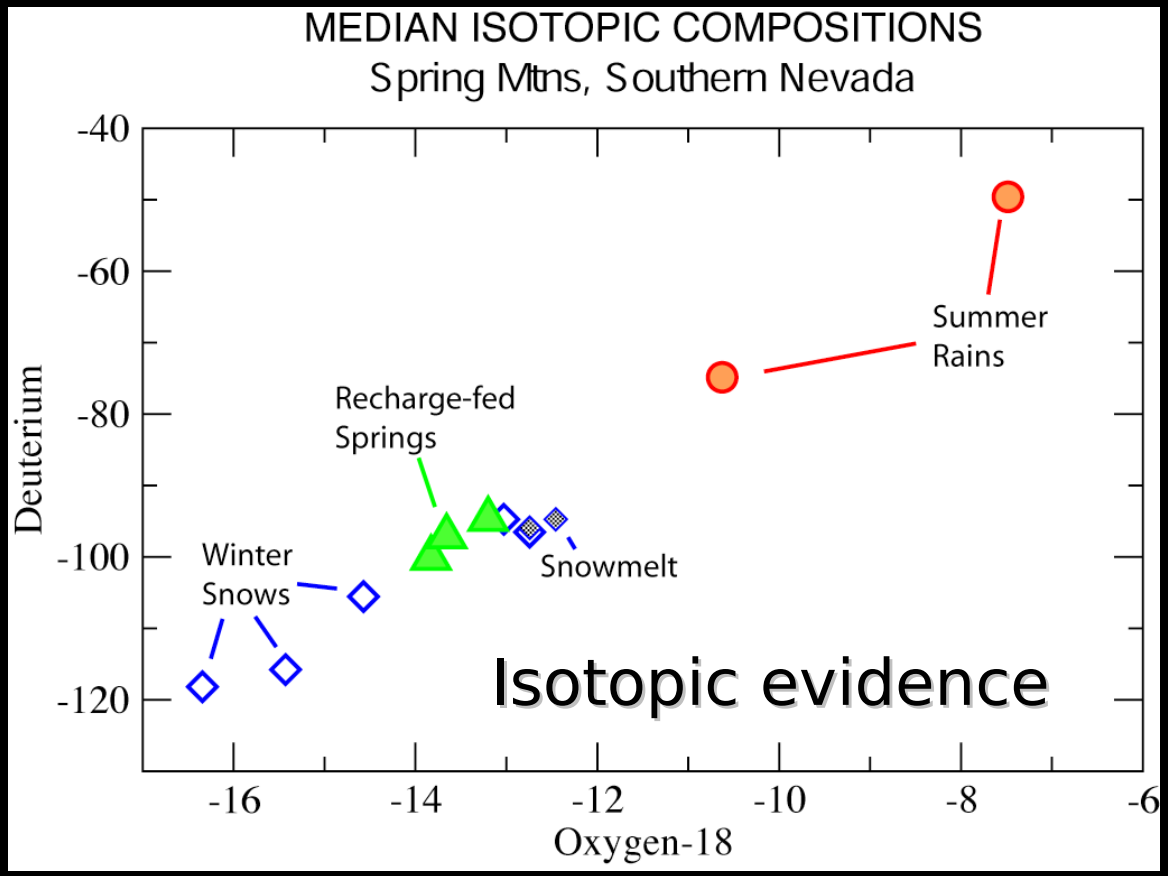


USGS

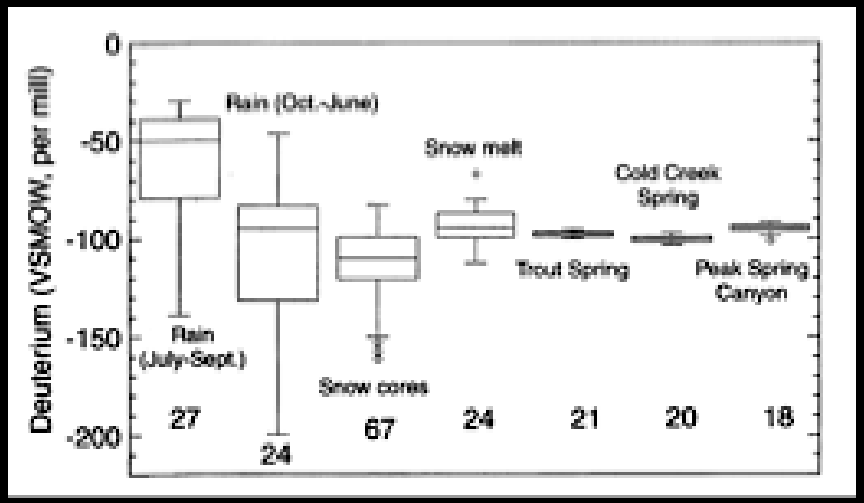
Changnon, 1987

In arid-semiarid zones, recharge comes preferentially from snowmelt.

An example from the Great Basin



Winograd et al., 1998

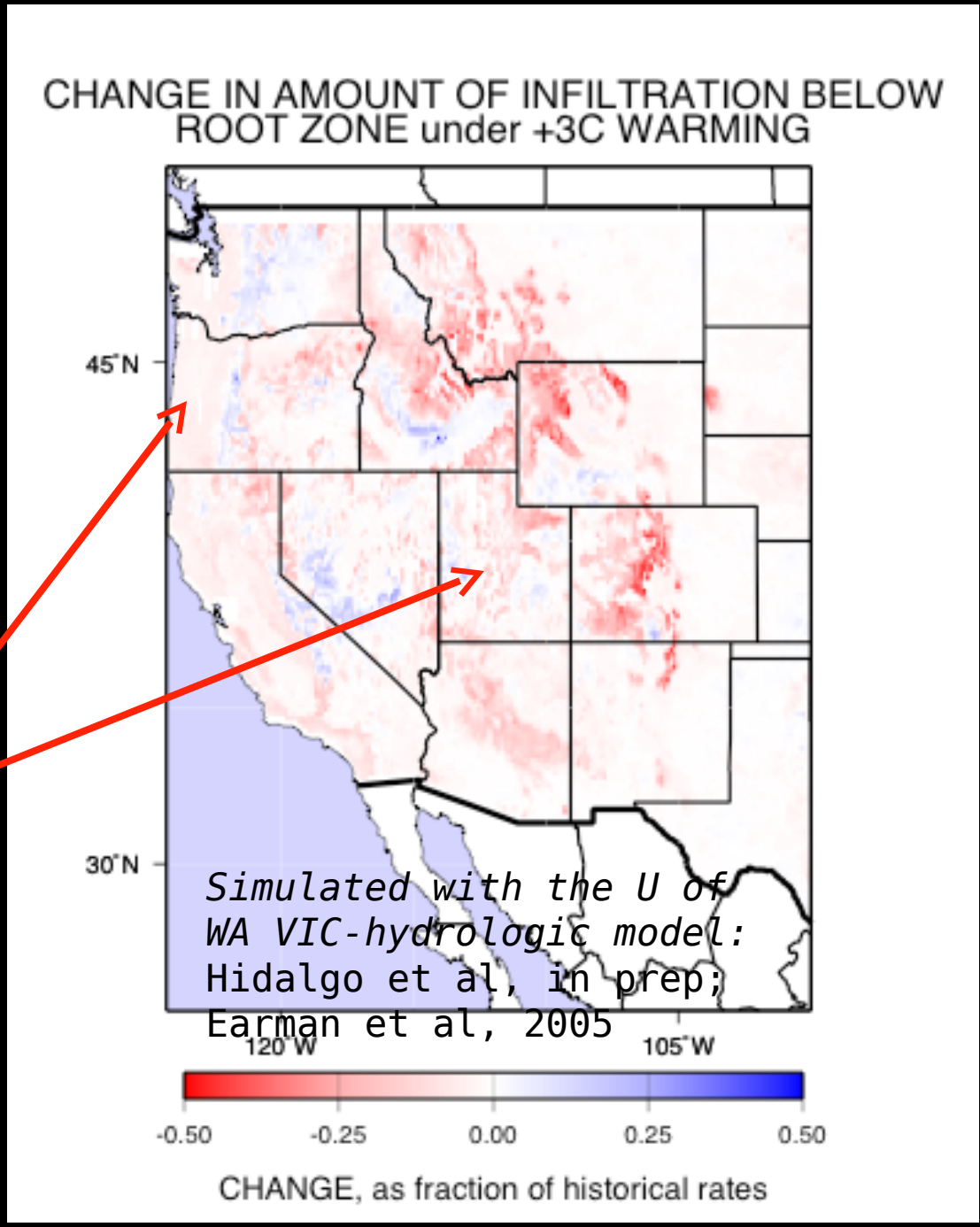


USGS

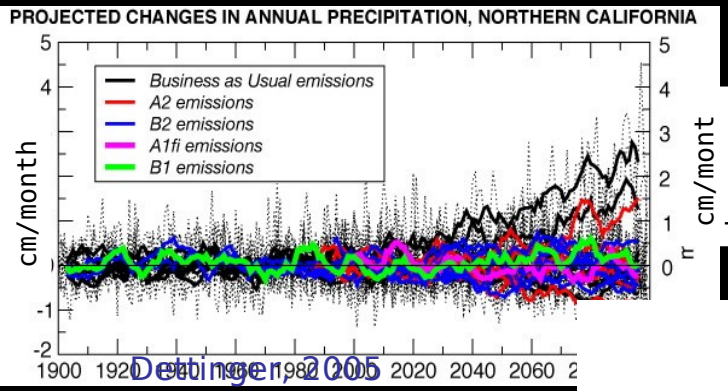
Thus, as snowpacks decline and rainfall takes over, RECHARGE may tend to decline in much of the West.

SIMULATED CHANGES IN RECHARGE under a uniform +3ºC warming

Widespread 15 to 25% changes projected, mostly as declines in recharge



USGS

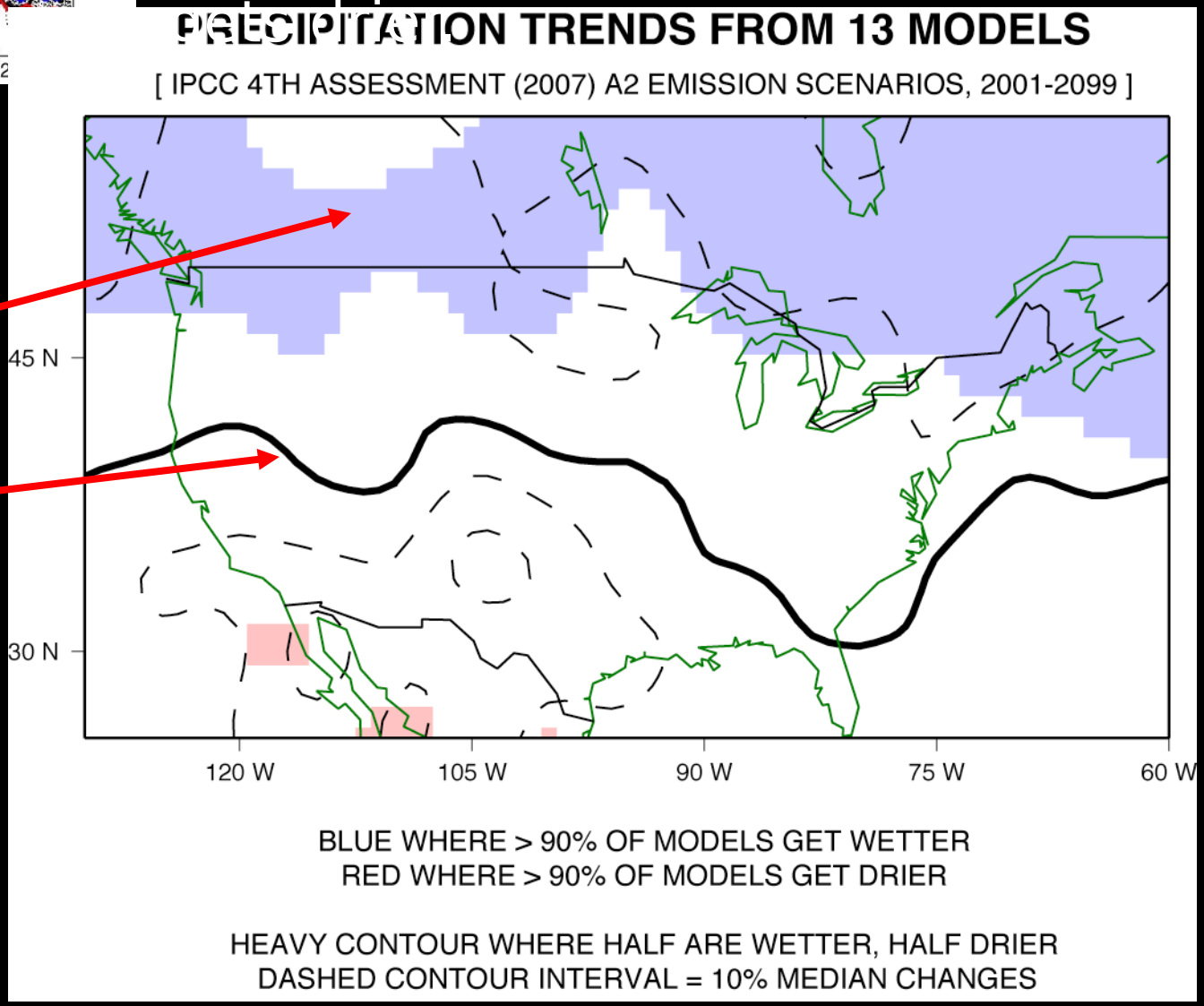


Dettinger, 2005

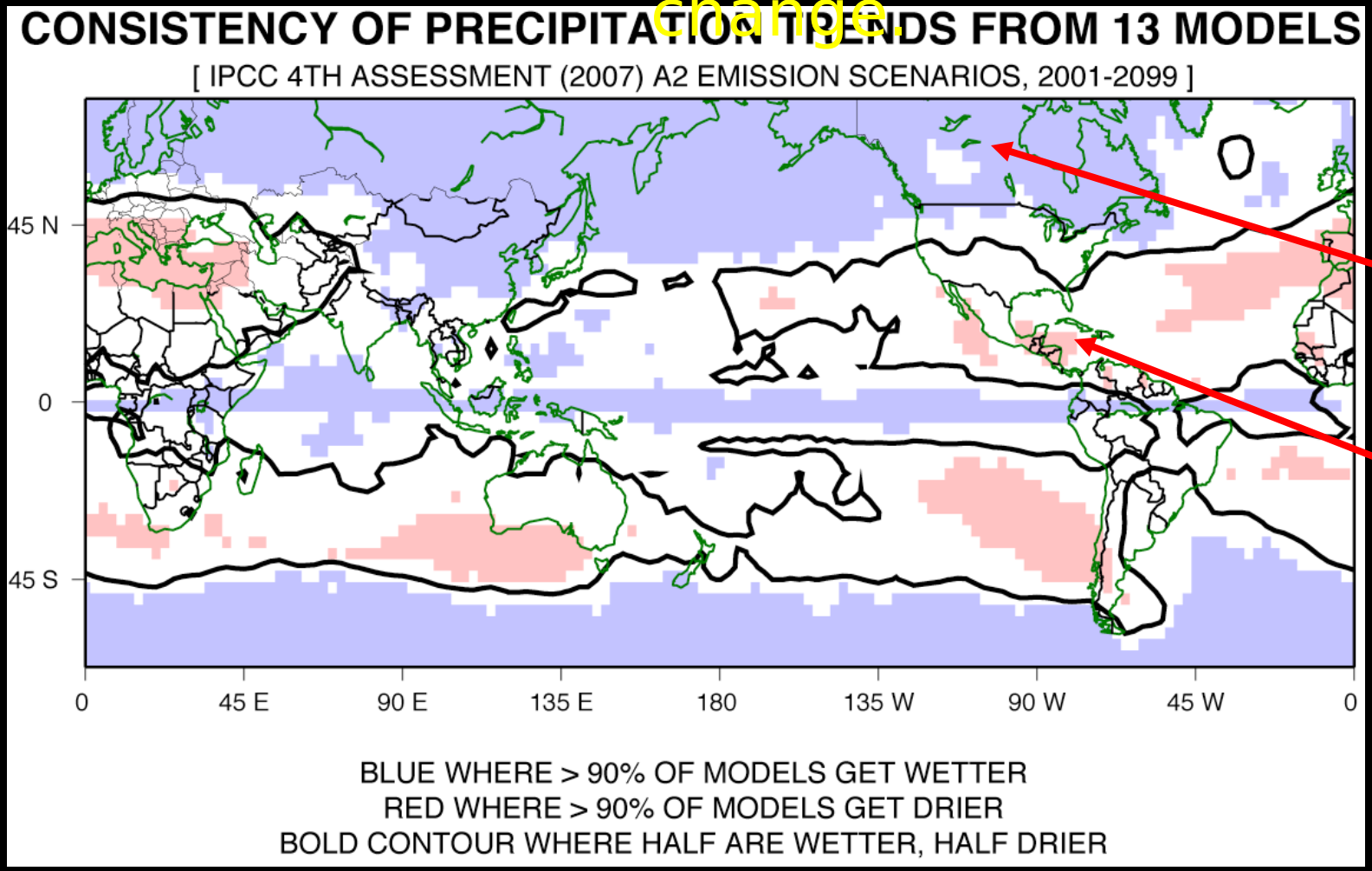
Across most of the central/north West, current climate models project small changes in precipitation. SW notable is

Only northernmost states show consistency.

Zero-change contour thru middle of country.


PRECIPITATION TRENDS FROM 13 MODELS
[IPCC 4TH ASSESSMENT (2007) A2 EMISSION SCENARIOS, 2001-2099]
45 N
30 N
120 W
105 W
90 W
75 W
60 W
BLUE WHERE > 90% OF MODELS GET WETTER
RED WHERE > 90% OF MODELS GET DRIER
HEAVY CONTOUR WHERE HALF ARE WETTER, HALF DRIER
DASHED CONTOUR INTERVAL = 10% MEDIAN CHANGES

This is not an accident, but rather is part of a global pattern of projections of precipitation change



Poles and tropical oceans get wetter.

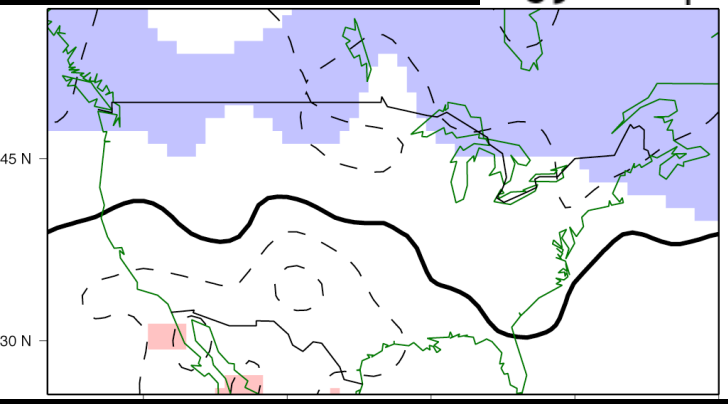
Subtropics get drier.

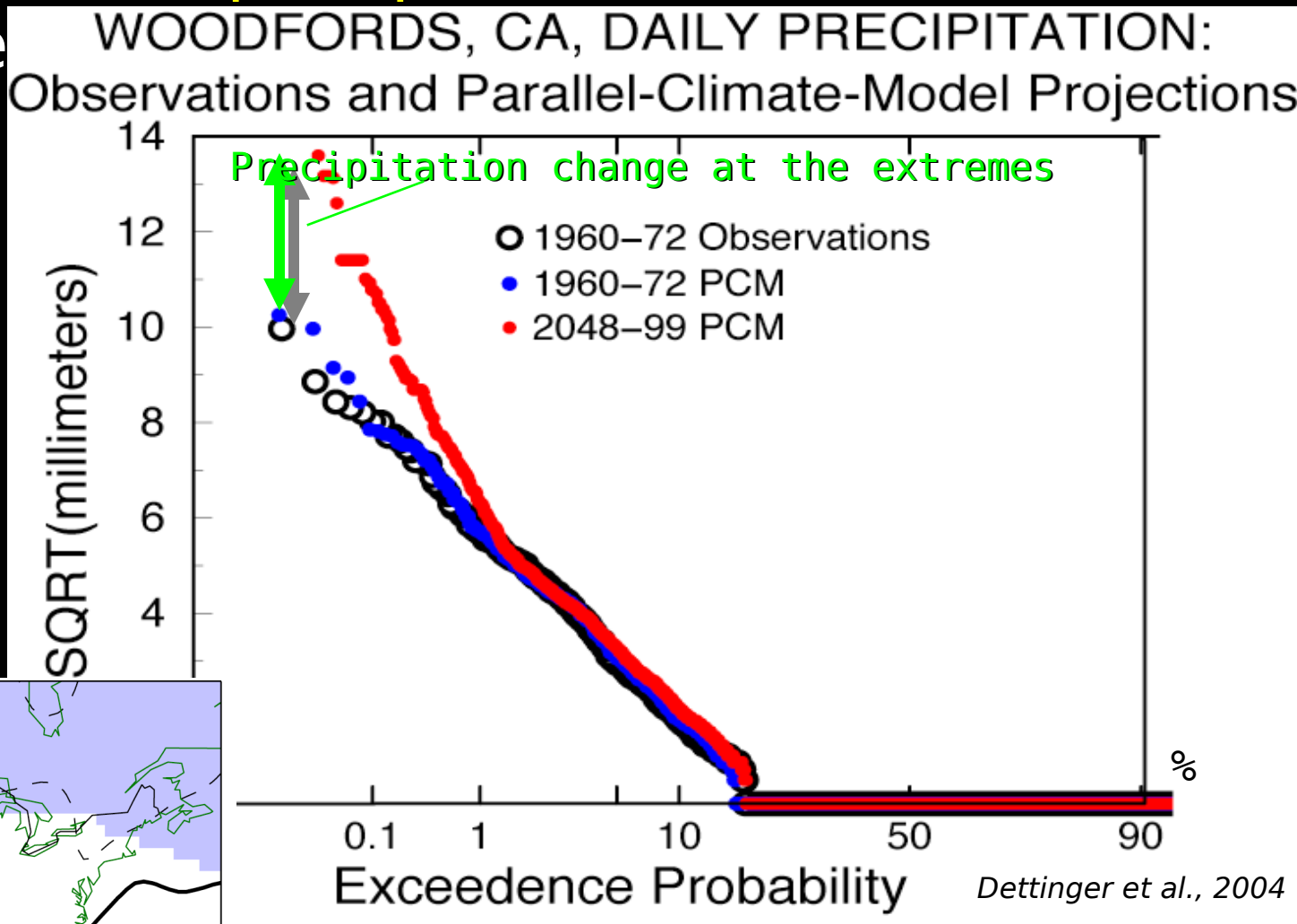
Most of contermino us US falls somewhere in between.

However, with high-lats getting wetter and desert belts getting drier, the VARIABILITY of precipitation

in middle

Results from the US Parallel-Climate Model, 2001, which yields small changes in AVERAGE precipitation





Dettinger et al., 2004

TO SUMMARIZE…

Warming by +2 to +6ºC,
likely more so at higher altitudes

Uncertain precipitation changes,
maybe more--maybe less, mostly
small

Significant changes in

- rain-vs-snow storms
- snowpack amounts
- snowmelt timing
- flood risk
- streamflow timing
- low flows
- growing seasons
- recharge?

just in response to temperatures